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REALIZATION OF INDUCTANCE AND REQUIREMENTS FOR SURGE CURRENT TESTING

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ABSTRACT

 Surge current testing is taken into account one among the foremost necessary techniques to judge reliableness and/or sort doubtless defective atomic number 73 capacitors for low-impedance applications. Analysis of this check, because it is represented within the MIL-PRF-55365 document, shows that it doesn't address many problems that square measure necessary to assure adequate and consistent testing. This work investigates the impact of inductance of the check circuit on voltage and current transients and analyzes necessities for the weather of the circuit, specifically, resistance of the circuit, inductance of

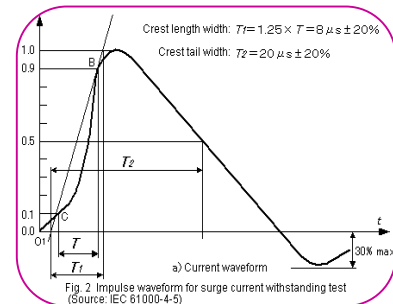*wires and resistors, sort of change devices, and characteristics of energy storage bank capacitors*

KEYWORDS: *Surge current testing , judge reliableness.*

1. INTRODUCTION

 High current spikes caused by power provide transients would possibly end in short-circuit failures of atomic number 73 capacitors and cause harmful consequences for electronic systems, together with igniting the system. The likelihood of this sort of failure is particularly high for low-impedance circuits once inpouring currents square measure restricted largely by the electrical resistance of the condenser itself [1]. Recently, these issues have gained nonetheless additional importance because of proliferation of distributed-power design systems and low-tension DC-DC converters. Failures because of surge currents continually are a significant concern for makers of atomic number 73 capacitors and for style engineers. To sure inpouring currents, application of limiting resistors was powerfully suggested. First, within the Nineteen Sixties, the need was three Ohms per every V of in operation voltage, however by the Nineteen Eighties, because of improvement in reliableness of the components and powerful business ought to increase the potency of power provide systems, this demand was reduced to one Ohm and within the Nineteen Nineties even to zero.1 Ohm per V [2, 3]. To additional assure reliable operation of atomic number 73 capacitors in low-impedance applications, derating of the voltage to five hundredth and even twenty fifth of the capacitor's rated voltage is suggested [1]. However, in [4, 5] the authors argue that this rule for derating isn't essentially correct for brand new high-quality product. These trends clearly indicate an inclination of each designers and makers to additional decrease stripped-down values of limiting resistors and to relax necessities for derating, so increasing in operation voltages of atomic number 73 capacitors in low-impedance applications. During this scenario, it's necessary to own a clearly belowstood and tested methodology permitting consistent and reliable analysis of performance of the capacitors under high surge current stress conditions. The capability of atomic number 73 capacitors to face up to high current transients is evaluated throughout surge current testing represented for chip atomic number 73 capacitors within the MIL-PRF-55365 normal. For hermetically sealed atomic number 73 capacitors, similar check (with some minor variations) is represented in MIL-PRF-39003. Surge current testing consistent with these standards is additionally suggested to sort

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doubtless weak components for high-reliability area applications [6]. According to MIL-PRF-55365, the half is subjected to ten surge cycles in a very circuit almost like the one shown in Figure one. every cycle includes charging a bank energy storage condenser, CB, to the rated voltage for four seconds then discharging it to the device below check for four seconds and dynamical the switch to the higher position. the aim of condenser CB, that is needed to be not but fifty,000 µF, is to simulate an influence provide with low electrical resistance. The quality needs that the entire DC resistance of the circuit, RC, together with the wiring, fixturing, and output electrical resistance of the ability provide, shall be a most of one.2 Ohms.
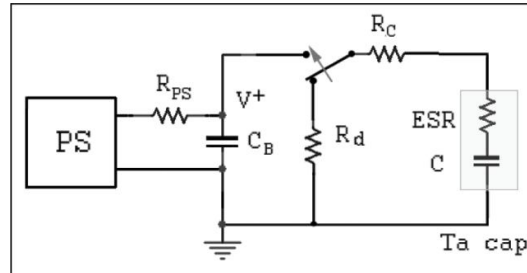

Figure 1. A simplified schematic of the surge current test per MIL-PRF-55365.

Some authors [2, 5] have indicated that inductance of the circuit might increase the probability of failures during surge current testing. However, no analyses of conditions that would cause failures and/or requirements to limit the value of the inductance have been given.

II. Inductance of elements of the test circuit.
. Inductance of capacitors.
Frequency dependencies of resistivity, Z, of atomic number 73 capacitors have a questionable self-resonance frequency, fr, at that the resistivity reaches minimum. the worth of metal for these elements is taken into account to be within the vary from zero.2 to one megahertz [3]; but, recent information indicate that metal may well be as high as a pair of to three megahertz [1]. The behavior of Z-f characteristics are often explained assumptive that the equivalent circuit of a atomic number 73 condenser are often diagrammatical as a condenser, inductor, and electrical device connected serial. For this circuit the resistivity Z and its modulus |Z| are often calculated as:

$$Z = (ESR) + j\omega(ESL) - \frac{j}{\omega C}$$

$$|Z| = \sqrt{(ESR)^2 + \left(\omega \times (ESL) - \frac{1}{\omega \times C}\right)^2},$$

where ω is the radian frequency and ESR and ESL are the effective series resistance and inductance of the capacitor, respectively. The self-resonant frequency can be defined as:

Ceramic capacitors show similar characteristics and even have self-resonant frequencies, that area unit generally bigger compared to Ta capacitors. this can be thanks to each lower C and lower ESL values of ceramic components. an summary of inductive properties of various styles of low-tension capacitors is given by Ewell [1]. Associate in Nursing increasing want for decoupling of signals in advanced high-frequency microcircuits and processors stirred multiple theoretical and experimental studies of inductance characteristics of chip ceramic capacitors. Typically, the inductance of those components varies from four to five nanohenries (nH) for leaded [2] to one.1 to 1.7 American state for 2225-style chip capacitors [3], to 0.18 American state for 1206-style capacitors [4], and to 0.4 – 0.9 American state for 0805-style capacitors [1].

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Special-design, small-value ceramic capacitors may need inductance as low as fifty pH scale [5]. Much less is understood regarding the inductance of Ta capacitors. in line with Derksen at al. [5], each chip ceramic and Ta capacitors have similar inductance within the order of 1-3 American state looking on their size. However, Martin [4], employing a quick edge rate current pulse technique, has shown that zero.1 one ceramic capacitors have a pair of.5 times less inductance compared to constant nominal Ta capacitors, that had L ~ twelve.5 nH. This price is in keeping with ten.9 nH for 5.6 vi low ESR Ta capacitors rumored in [1]. almost like chip ceramic capacitors, ESL values of Ta capacitors don't correlate with values of capacitance and/or rated voltage and stay at intervals comparatively slim limits for a given size of the components [3]. However, inductive characteristics of Ta chip capacitors haven't been studied properly nonetheless and there are not any specifications for ESL measurements. The inductance of a capacitance consisting of 2 parallel plates of dimension W, length l, and distance between the plates d, may be calculated as [1]:

$$f_r = \frac{1}{2\pi \times \sqrt{C \times (ESL)}}.$$

At relatively low frequencies, f < f_r, the part behaves as a capacitor, and at f > fr as an inductor.

$$L = \mu\mu_0 \frac{d \times l}{W},$$

where μ_o = 1.26×10^{-6} H/m is the permeability of free space and μ is the permeability of the dielectric.

Thirteen pH scale. this can be an especially little worth, and even considering inductance of the terminals, which generally doesn't exceed one nanohenry, the discrepancy between the calculations and experimental knowledge remains rather vital. it's quite attainable that the heterogeneousness of the cathode and, specially, micro-irregularities within the physical phenomenon of the Mn layer, don't allow identical distribution of the present density in Ta and Mn electrodes, in order that the field of force outside the electrical device isn't remunerated fully. This may increase the inductance and cause higher ESL values of Ta capacitors compared to ceramic components of the same size. A simple methodology for ESL analysis would be direct measurements of frequency dependencies of active and reactive resistances of the half. In our experiments these measurements were dole out within the vary of frequencies from zero.1 kilohertz to one0 megahertz on many CWR09-style capacitors mistreatment associate electrical resistance instrument HP4192A with a right away coupled take a look at fixture. Calculations supported these experiments showed that the inductance will increase with frequency and levels off at f higher than ~ two megahertz leading to ESL varied from eighty New Hampshire to a hundred and ten New Hampshire. However, throughout discussion with Erik Reed (JPL), he has indicated that these values aren't according to the info obtained by direct measurements of high-frequency electrical resistance for these components and instructed an easy technique for ESL assessment. Figure two shows a schematic for Z-f measurements employing a high-frequency generator with the output restricted by a 50-Ohm electrical device and electronic equipment connected on to the terminals of the electrical device with short concentric cables≈Considering that for a Ta oxide nonconductor nonconductor nonconductor one and also the effective space generally is ~100 cm2 and d ~ zero.1 μm, for rough estimations it's attainable to assume l = one,000 metric linear unit and W = ten metric linear unit. At these conditions calculations yield L
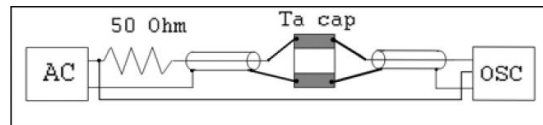
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Figure 2. A set-up for measurements of high-frequency characteristics of tantalum capacitors.

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Measurements of the input and output signals allowed for the part shift and resistance calculations. Results of those calculations for 2 T495X156M050AS capacitors within the rage of frequencies from one kilocycle per second to twenty rate square measure shown in Figure three.
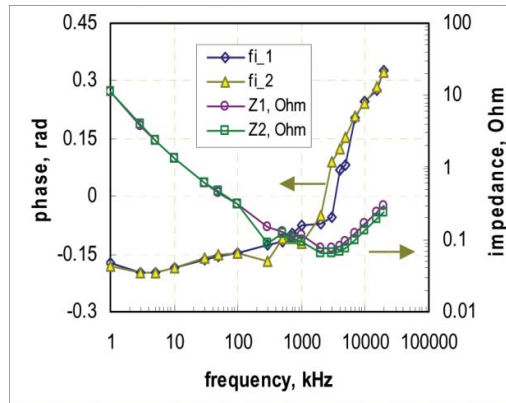

Figure 3. Frequency dependence of the impedance and phase shift for two T495X156M050AS capacitors.

CONCLUSION

The discrepancy compared to the results obtained victimization the ohmic resistance instrument is presumptively because of parasitic inductance and inadequate compensation of the fixture. supported the out there information, ESL of chip Ta capacitors square measure seemingly within the vary from two to fifteen Granite State with higher values reminiscent of larger-sized components.

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